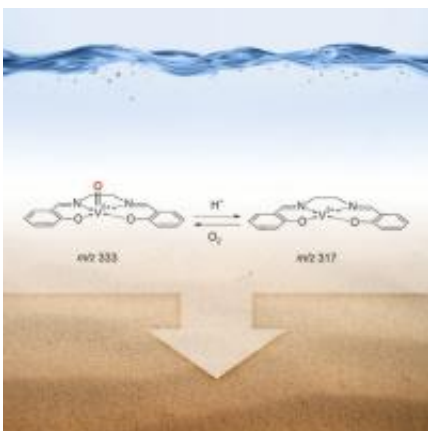


# Soft landing metal-based molecules create active, easy-to-separate catalyst

January 27 2011

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Scientists at Pacific Northwest National Laboratory, Purdue University, and National Dong Hwa University in China used an ion soft landing technique to gently deposit catalytic and acidic molecules on a tailored, “dry” surface. The dry catalyst drives the reaction in a similar fashion to the liquid-phase version; however, because the catalyst is on a solid surface, it is easy to separate from the remaining reactants and products.

A vanadium-based catalyst's effectiveness in acidic liquids can be mimicked on a solid, less-toxic surface, thanks to scientists at Pacific Northwest National Laboratory, Purdue University, and National Dong Hwa University in China. The team used an ion soft landing technique to gently deposit catalytic and acidic molecules on a tailored, "dry" surface. This new material drives the reaction in a similar fashion to the liquid-phase version, and it is better in one significant way: the catalyst is on a

solid surface, making it easy to separate from the remaining reactants and products after the reactions. This avoids expensive post-processing steps.

Technologies to turn intermittent power sources into use-any-time sources of energy require fuel cells that use yet-to-be-invented catalysts. In addition, the chemical and petroleum industries crave more efficient catalysts for their reactions. Scientists at PNNL and elsewhere are working to design these efficient, easy-to-separate catalysts. But before the materials can be designed, scientists must understand how catalysts behave at the atomic and molecular levels.

"Our soft-landing study provides a fundamental understanding of the phenomena that occur when catalytic [molecules](#) are tethered to the surface," said Dr. Grant Johnson, a physical chemist and a Linus Pauling Distinguished Postdoctoral Fellow at PNNL.

Something happens when you tether a molecule to a surface. To understand what happens to certain catalyzing molecules, the scientists began with VVO(salen)<sup>+</sup>. This is an organometallic catalyst, meaning it has a metal center or active site wrapped in [organic molecules](#). Vanadium was selected as the metal center because of its activity and ease of study.

The team generated the catalyst and a nickel-based acid or proton donor, [Ni<sup>III</sup>(salen) + H]<sup>+</sup>, by electrospray ionization. Then, they used the ion soft-landing apparatus at EMSL to deposit the catalyst and the acid onto a specialized surface. This surface is a thin layer of gold topped with an inert nanometer-thick carbon-fluoride layer.

"Ion soft landing enables us to gently deposit a broad range of molecules on surfaces," said Dr. Julia Laskin, a physical chemist and principal investigator at PNNL. "And the soft landing method is selective,

meaning that we know exactly what we deposit."

They studied the catalyst and acid under ultra-high vacuum. They found that over four days, the vanadium catalyst drove a reaction that combines oxygen and hydrogen, creating water. This reaction is critical to fuel cells.

After examining the results, the researchers decided to see if the reaction occurred when acids other than  $[\text{NiII}(\text{salen}) + \text{H}]^+$  were used. It did. They tried the reaction without an acid and found that the catalyst was inactive.

The researchers determined that the acid donated a proton to the surface. The proton, in turn, made the [catalyst](#) active. "A few years ago, we were watching molecules lose protons when attached to surfaces," said Laskin. "Here, we are seeing that the surface protons induce some very interesting chemistry."

The researchers are studying larger metal-centered catalysts and catalytically active nanoparticles using the soft landing approach.

**More information:** Peng WP, et al. 2011. "Redox Chemistry in Thin Layers of Organometallic Complexes Prepared Using Ion Soft Landing." *Physical Chemistry Chemical Physics* 13(1), 267-275. [DOI: 10.1039/c0cp01457e](#)

Provided by Pacific Northwest National Laboratory

Citation: Soft landing metal-based molecules create active, easy-to-separate catalyst (2011, January 27) retrieved 25 April 2024 from <https://phys.org/news/2011-01-soft-metal-based-molecules-easy-to-separate-catalyst.html>

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